

# In-Use Off-road Diesel Vehicle Rule Workshop



**December 18, 20, and 21, 2006**  
**Sacramento, Los Angeles, and Fresno, California**

**Heavy-Duty Diesel In-Use Strategies Branch**

**California Environmental Protection Agency**

---



**Air Resources Board**

# Overview

- Emissions inventory
- Need for emissions reductions
- Emissions control systems
- Proposed regulation
- Cost and cost-effectiveness
- Next steps



# Emissions Inventory



# Inventory Update Overview

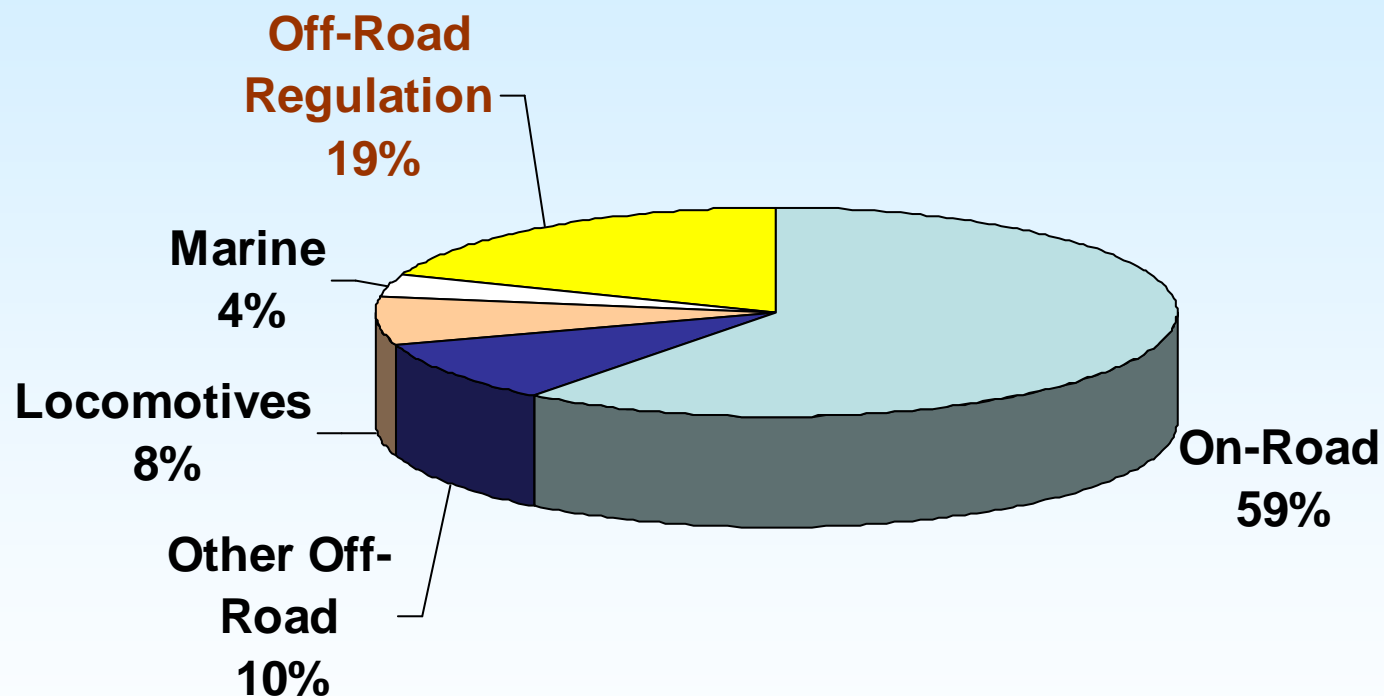
- Current statewide emissions (tons/day)
- Updated input data
  - Population
  - Activity
  - Useful Life & Age Distribution
  - Growth Assumptions
  - Emission Factors
- Summary

# Off-Road NOx Emissions

Statewide (tpd)

Year	Construction	Industrial	GSE	Oil Drilling	Total
2005	332	40	6	19	397
2010	274	32	5	16	327
2015	204	22	4	13	242
2020	138	13	3	10	164

# Mobile Sources Diesel Emissions NO<sub>x</sub> 2005

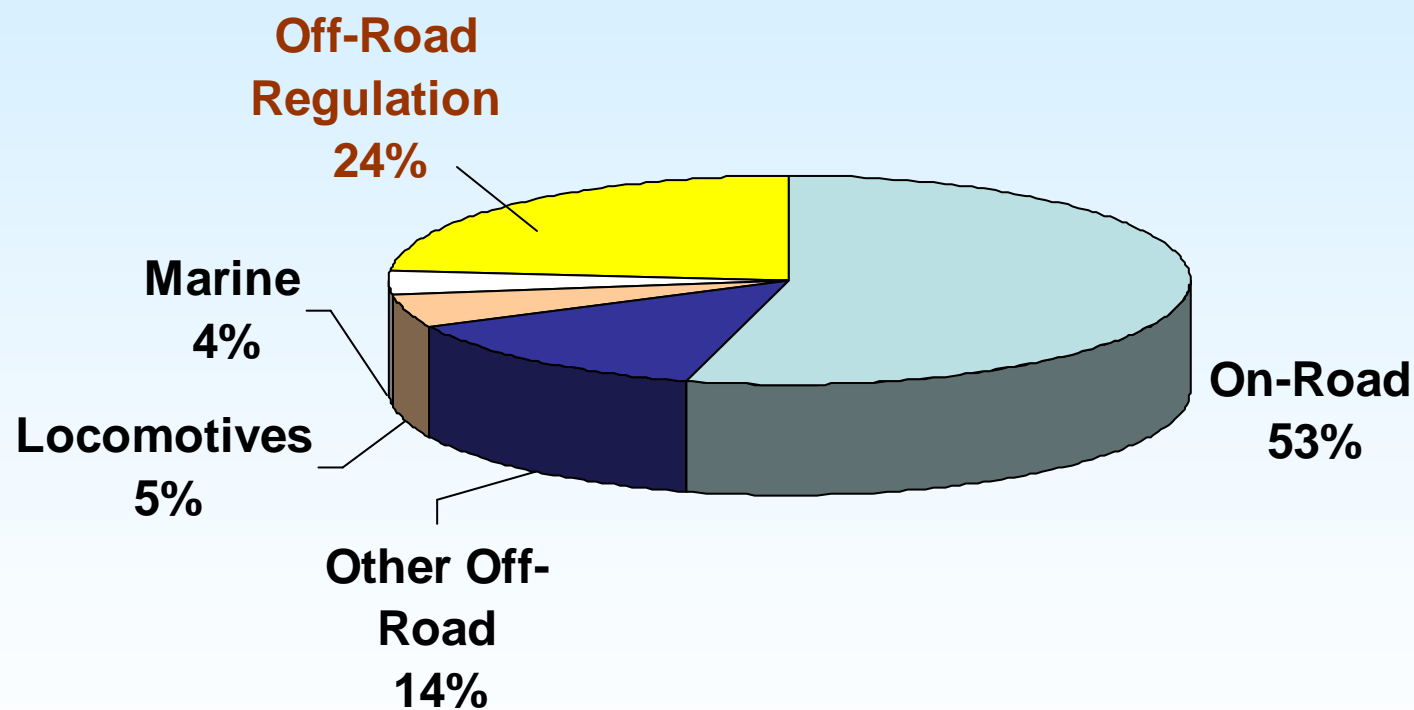


# Off-Road PM Emissions

## Statewide (tpd)

Year	Construction	Industrial	GSE	Oil Drilling	Total
2005	20	2	.36	.97	23
2010	16	2	.31	.76	19
2015	11	1	.24	.58	13
2020	6	1	.16	.41	8

# Mobile Sources Diesel Emissions PM 2005





# Inventory Update Process

- Previous off-road diesel inventory developed in 1999
- ARB held 6 workgroup meetings with stakeholders to gather input and data
  - From December, 2004 through July, 2006
- In July 2006, the inventory was updated based on:
  - MacKay & Co. Construction Universe Study (2003)
  - TIAX Public Fleet Survey (2003)
  - Yengst equipment analysis reports (2005)
  - ARB Off-road Equipment Survey (2005)
  - ARB Off-road Mini Survey (2006)
  - Input from stakeholders
- OFFROAD2007 Model incorporated this updated diesel inventory in November 2006

# Population

- Construction & Mining Population
  - Data from MacKay study (2003) & ARB's 2005 Off-Road Equipment survey
- Industrial Population
  - From Power Systems Research (2000); U.S. EPA's NONROAD Model
- GSE Population
  - From Air Transport Association (ATA) 2004 survey
- Oil Drilling Population
  - From ARB's 2006 Off-Road Mini survey & stakeholders input

# Vehicle Population

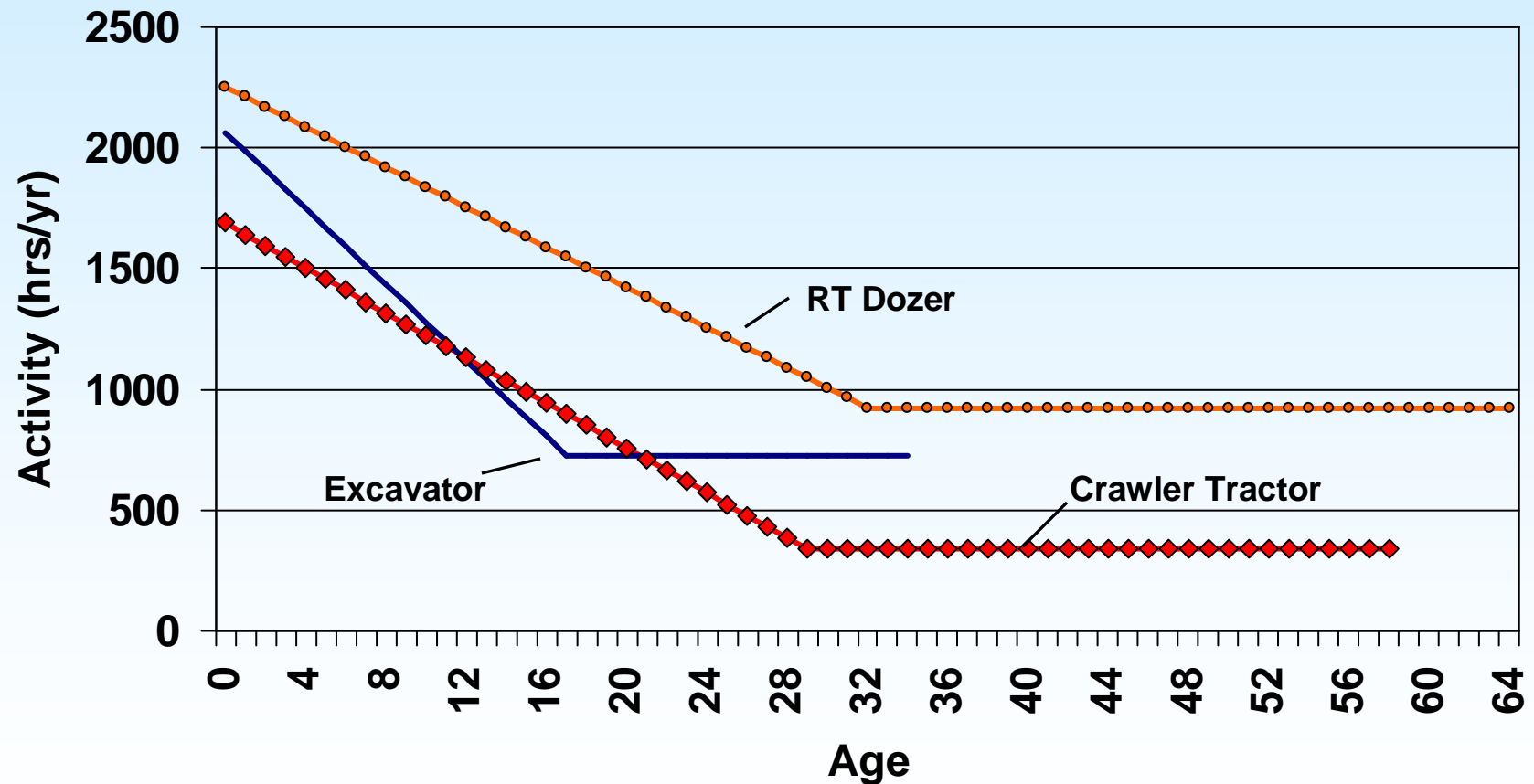
## Statewide

Year	Construction	Industrial	GSE	Oil Drilling	Total
2005	161,302	19,592	2,662	1,021	184,578
2010	175,698	20,235	2,916	1,021	199,870
2015	190,088	20,676	3,133	1,021	214,918
2020	204,484	20,892	3,254	1,021	229,651

# Annual Activity

- Construction & mining
  - Data from MacKay study (2003) , ARB's Off-Road Equipment survey (2005), TIAX survey (2003)
  - Annual activity now varies with age
    - Usage is assumed to decrease with age
- Industrial
  - From ARB's Off-Road Equipment survey (2005)
- GSE
  - Data from ARB's Off-Road Equipment survey (2005)
- Oil Drilling (Mobile)
  - From ARB's 2006 Off-Road Mini survey & stakeholders input

# Annual Construction Activity by Age

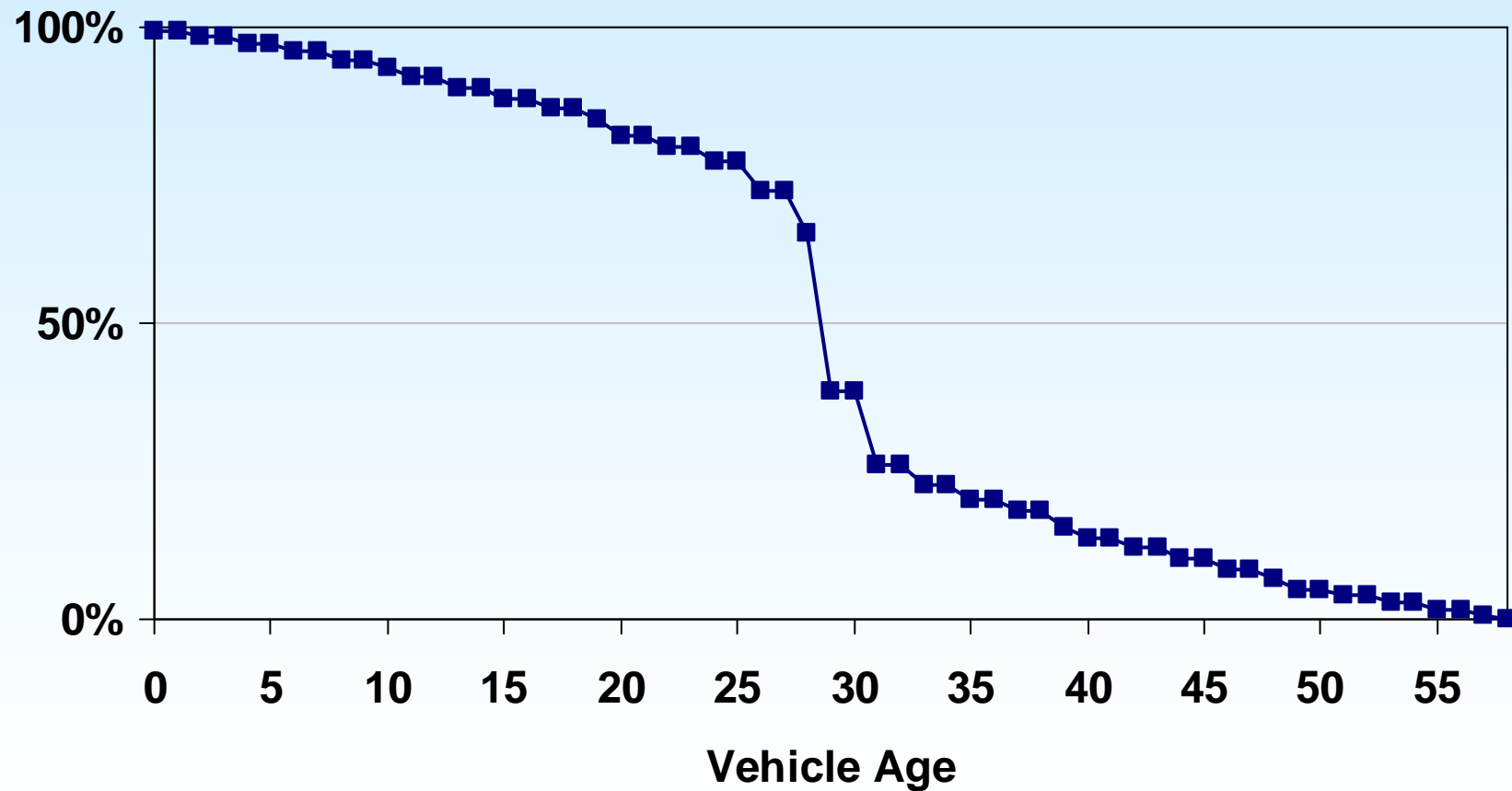


# Useful Life & Age Distribution

- Construction & Mining
  - Average age data from MacKay study (2003) & ARB's Off-Road Mini survey (2006)
- Industrial
  - Unchanged (Power Systems Research (1996))
- GSE
  - Data from Air Transport Association (ATA) survey (2004)
- Oil Drilling (Mobile)
  - From ARB's 2006 Off-Road Mini survey & stakeholders input

# Example Survival Curve

29 Year Useful Life



# Construction Equipment Population & Average Age (2005)

Top 10 Equipment Categories	Population (2005)	Age @50% Retired
Tractors/Loaders/Backhoes	30665	18
Skid Steer Loaders	29138	13
Rubber Tired Loaders	19580	21
Excavators	19354	17
Crawler Tractors	16130	29
Trenchers	8364	28
Rollers	7814	20
Graders	6777	23
Rough Terrain Forklifts	6771	16
Off-Highway Tractors	3215	31



# Tier Distribution

**% of Construction  
Equipment in Tier 0**

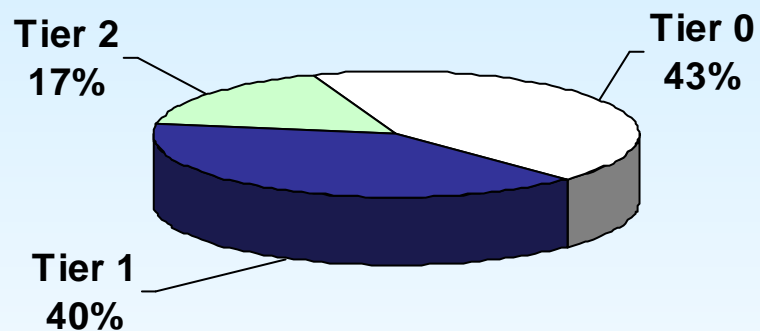
Year	Statewide
2005	52%
2010	30%
2015	15%
2020	8%

**% of Industrial  
Equipment in Tier 0**

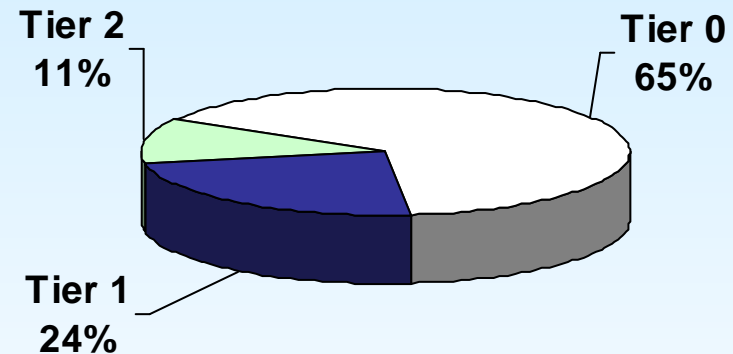
Year	Statewide
2005	39%
2010	17%
2015	5%
2020	2%

# Construction Category Tier Distribution

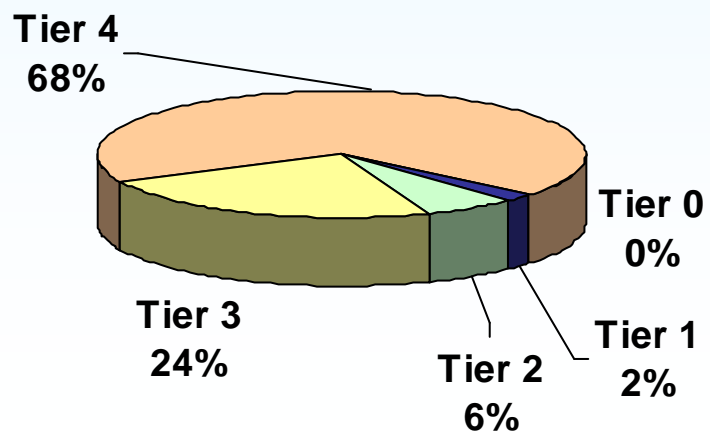
**Skid Steer Loader - 2005**



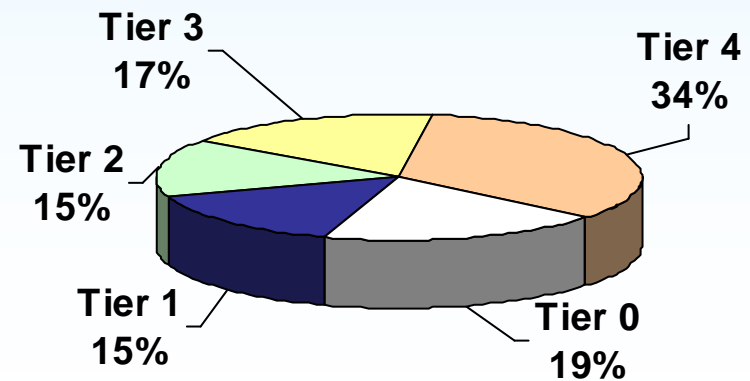
**Crawler Tractor - 2005**



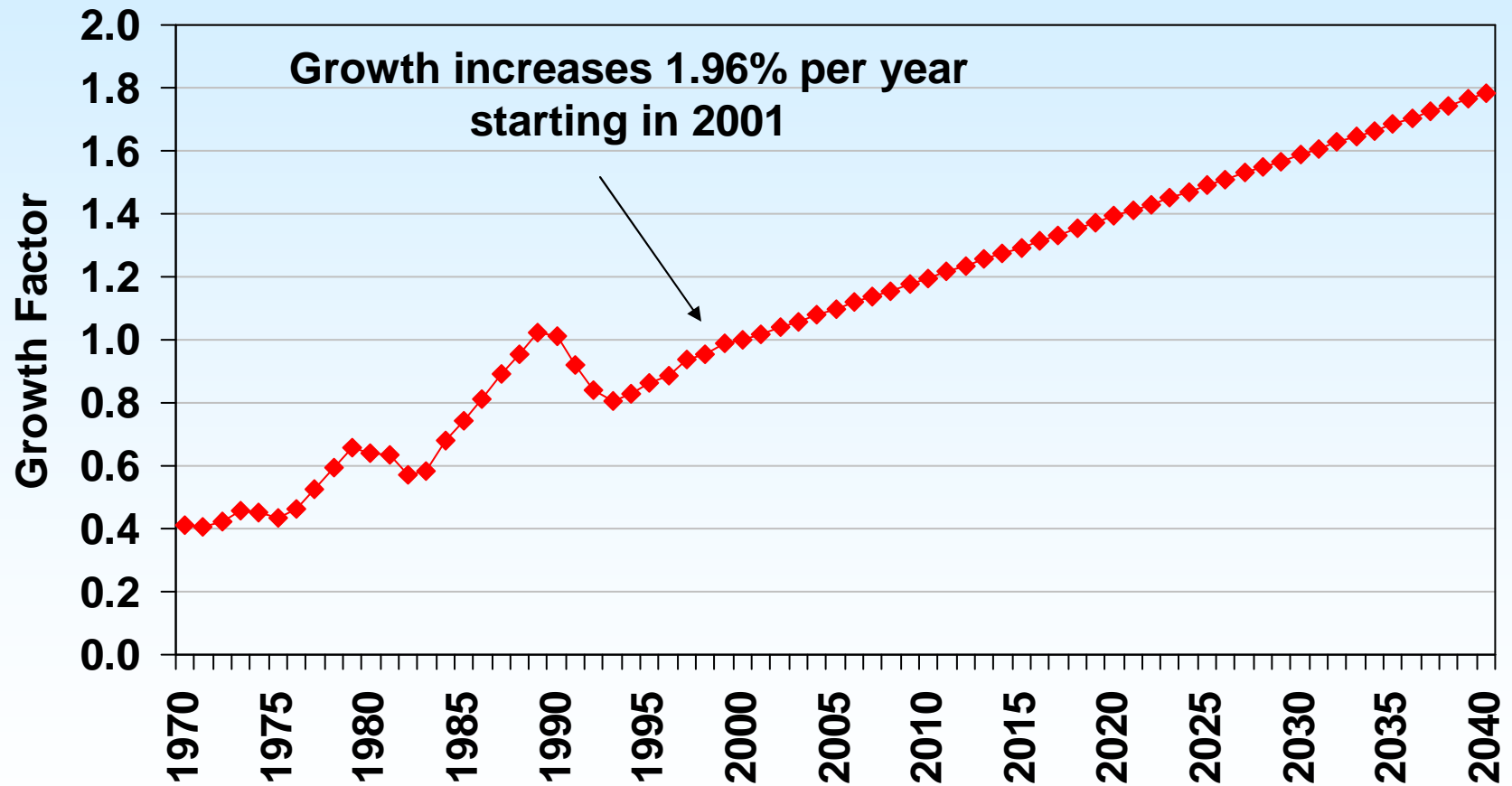
**Skid Steer Loader - 2020**



**Crawler Tractor - 2020**



# Construction Growth



# Emission Factors

- Incorporated U.S. EPA's Tier 4 emission factors for all diesel equipment (>25hp)
- Emissions capped at 12,000 hrs
  - To account for engine rebuild
    - ARB's 2005 Off-Road Equipment Survey
    - Input from stakeholders

# Emissions Inventory Summary

- Off-Road Diesel Emissions Inventory inputs are based on newer CY2003+ data
  - Data is California specific
  - Current trends reflected
    - Growth
    - Age distribution
  - Incorporated new Tier 4 diesel standards
- Resulted in:
  - Increase in Tier 0 equipment population
  - Accounts for 19% NOx emissions & 24% PM emissions from diesel mobile sources statewide

# Need for Emission Reductions



# Why are NOx reductions important?

- NOx reacts with ammonia in atmosphere to form particulate matter (PM<sub>2.5</sub>)
- Particulate Matter associated with:
  - Premature mortality
  - Hospitalization and emergency room visits for exacerbation of heart related diseases
  - Increased respiratory symptoms
  - Increased work loss days

# Why are NO<sub>x</sub> reductions important?

## Cont'd

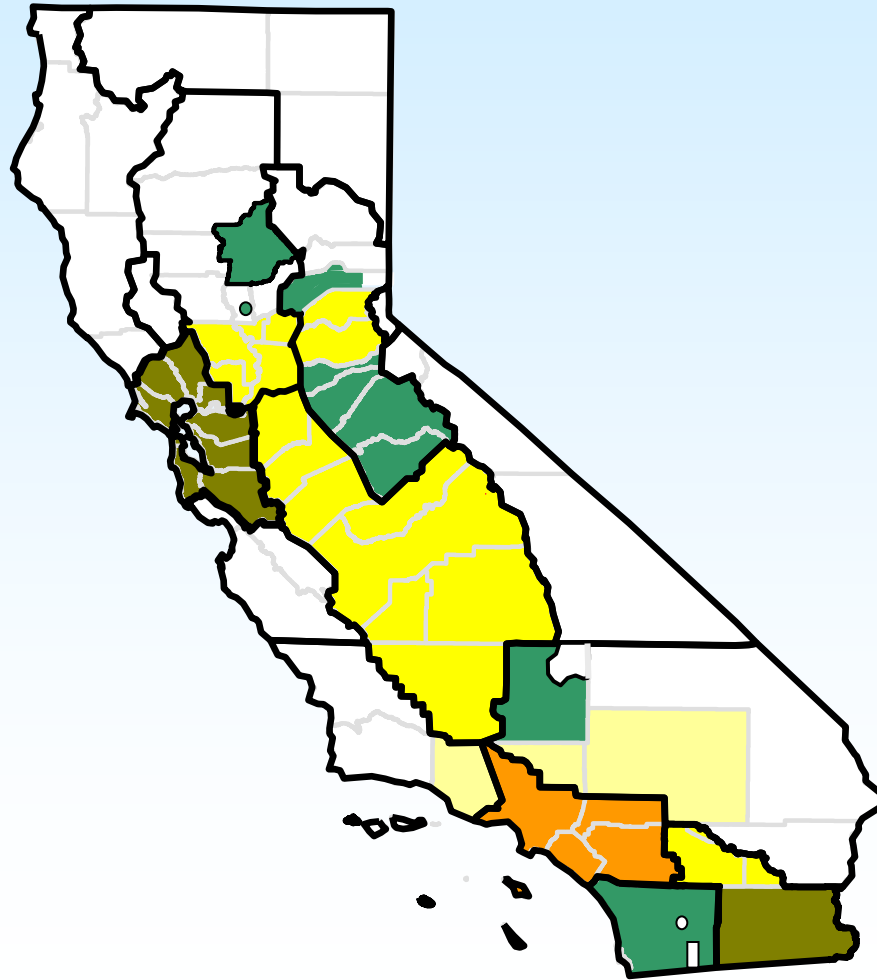
- NO<sub>x</sub> & volatile organic compounds react in sunlight to form ozone
- Ozone associated with:
  - Reduced lung function
  - Increased cough, chest tightness & school absences
  - Exacerbation and possibly development of asthma
  - Hospitalization for heart and lung related causes
  - Premature mortality in elderly



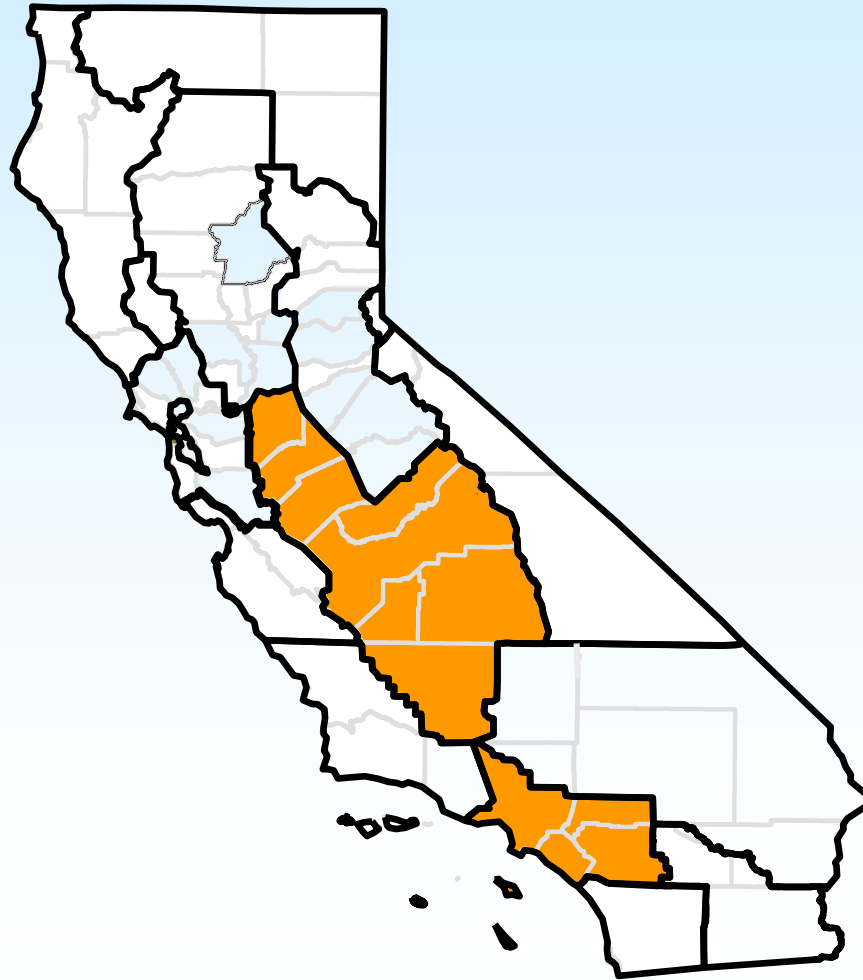
# Health and Legal Mandate

- Must protect the public's health
- Must attain standards set by United States Environmental Protection Agency
- Deadlines for attainment:
  - PM<sub>2.5</sub>: 2015
  - Ozone: 2007-2024

# 8-Hr Ozone Nonattainment Areas



# PM 2.5 Annual Nonattainment Areas



# State Implementation Plans (SIP)

- Roadmap to reaching standards
- Required by United States Environmental Protection Agency
- Compilation of adopted and proposed regulations that demonstrate attainment



# Statewide Strategy

- Driven by air quality in South Coast and San Joaquin Valley
- South Coast NOx reduction needs for PM<sub>2.5</sub>:
  - Preliminary reduction target (all categories): 25%-36% in 2015
  - Preliminary reduction target (Construction): 20% in 2015
- South Coast NOx reduction needs for Ozone:
  - Preliminary reduction target (all categories) ~50% in 2020
- SIP also relies on direct PM<sub>2.5</sub> reductions from rule

# SIP Sanctions

- If California does not adopt a plan that meets federal law:
- Federal Highway Transportation Funds frozen
  - \$1.2 billion in South Coast (FY2006)
  - \$340 million in San Joaquin Valley (FY2006)
- Projects depending on federal funds or approval halted
- Federal Implementation Plan

# Emission Control Systems



# Proposed Regulation





# Rule Overview

- Meet NOx and PM averages
  - Fleet averages decline over time

or

- Meet Best Available Control Technology (BACT) requirements
  - NOx - Turn over engines (10% of hp per year)
  - PM - Apply PM VDECS (20% of hp per year)

# Rule Overview

(Continued)

- Idling limits begin March 1, 2008
- Reporting required for all fleets beginning in 2008

Category	Description	Compliance Dates
Small	1500 hp or less and small business, or fleet owned by low population county or municipality	2012 to 2025
Medium	20,000 hp or less and not small	2010 to 2020
Large	Greater than 20,000 hp	2009 to 2020

# Rule Exemptions

- Exempt from NOx turnover requirements:
  - Vehicles less than 10 years old
  - Specialty vehicles if certain criteria are met
  - Vehicles retrofit with highest level VDECS in past 6 years
  - Tier 4 and interim Tier 4 engines
- Small fleets exempt from NOx requirements

# Rule Exemptions

(Continued)

- Exempt from PM retrofit requirements:
  - Engines in vehicles less than 5 years old
  - Engines for which there is no highest level VDECS
  - OEM engines with a diesel particulate filter
  - Engines already retrofit with a Level 2 or 3 device that was the highest level VDECS at time of installation

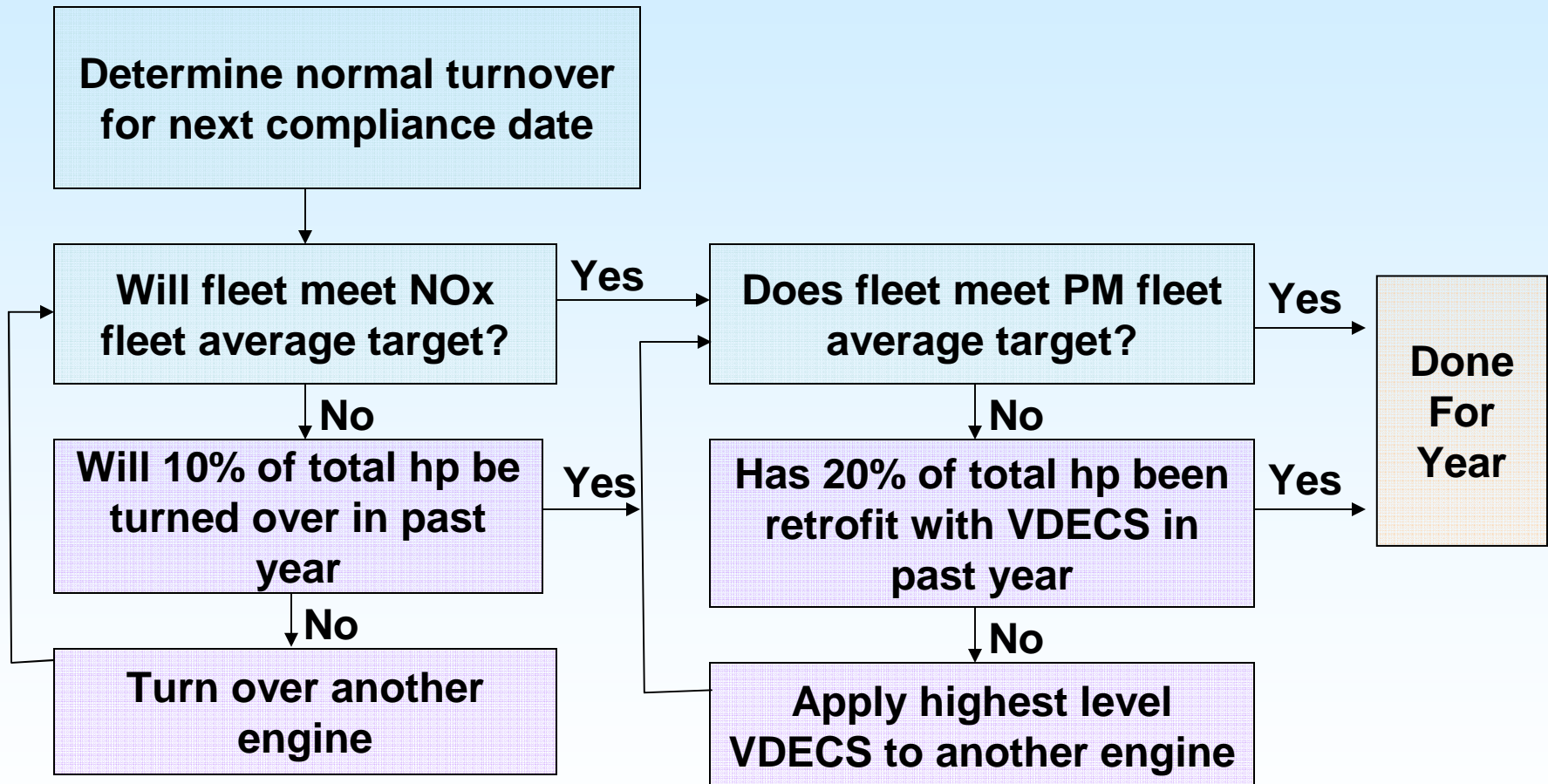
# Exempt from PM and NOx Requirements

- Vehicles operated in California less than 100 hours
  - Exemption applies until final compliance date
  - Non-resettable hour meter required
- Emergency vehicles
  - Use for emergency operations may be excluded in determining if low-use



# Compliance Process

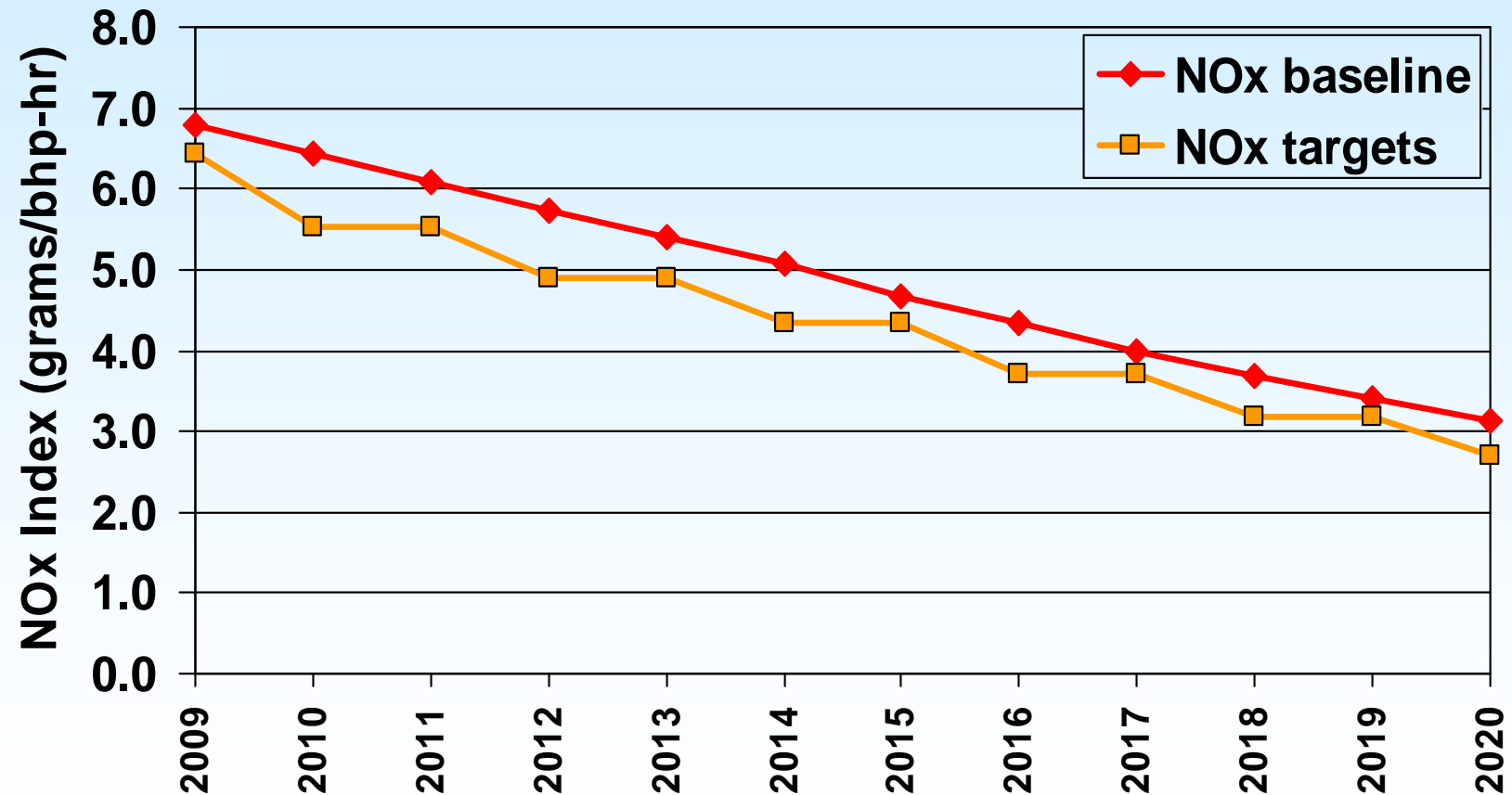
## Large and Medium Fleets



**Note:** Turn over means repower with cleaner engine, replace vehicle with used vehicle or new vehicle, or decrease fleet size.

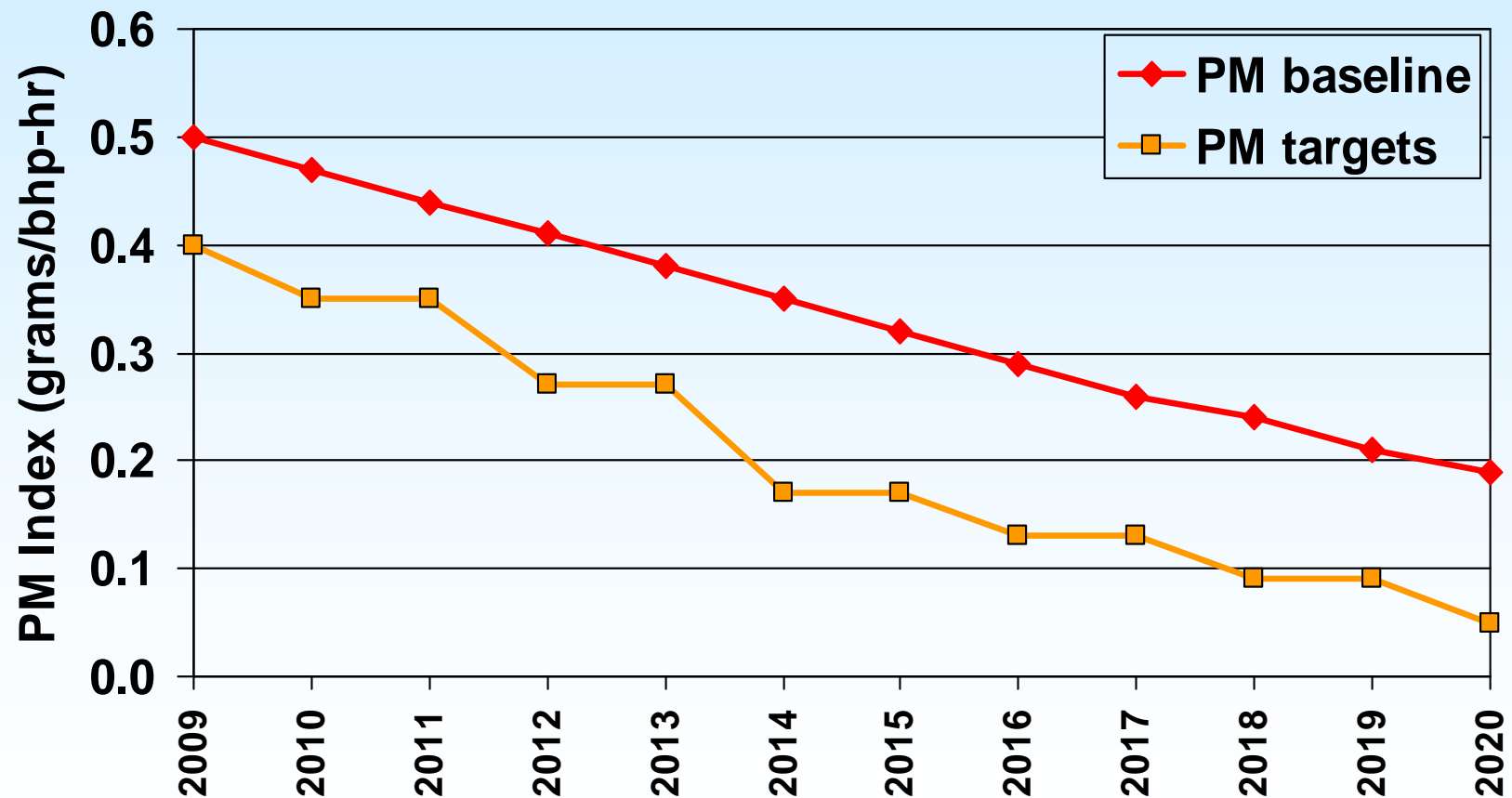
# NOx Targets vs Statewide Baseline

(Large and Medium Fleet Targets)



# PM Targets vs Statewide Baseline

(Large and Medium Fleet Targets)





# What Rule Will Mean for Fleets

- Newest vehicle fleets
  - No significant impact
- Oldest fleets (large/medium):
  - Accelerate turnover to 10%/yr
  - Retrofit 20%/year
  - Turn over oldest engines that were initially retrofit, once retrofits are older than 6 years.
- Typical small fleet:
  - Some retrofits, most beginning in 2014
- Older small fleets:
  - Retrofit 20%/year beginning 2014



# Electric and Alternative Fuel Equipment Can Help Meet Fleet Average

- Electric and alternative fuel vehicles can be counted if:
  - Replace diesel
  - Not used indoors
  - Not already counted in other rule's fleet average
  - Cleaner than diesel
- Electric GSE purchased prior to 2007 may be partially counted (Max hp times 0.2)
- Double credit for electric in 2009-2016
- Single credit for electric in 2017 and later
- Stationary or portable system used to replace mobile diesel vehicle can be counted in limited situations

# BACT Requirements: NOx Target Not Met

- Turn over 10% of total fleet max hp in previous year
  - May also demonstrate 10% on average annually since beginning of rule
  - Start with highest emitting engines (Tier 0 and Tier 1 with no PM standard)
  - Certain vehicles are exempt
- Repower with cleaner engine, replace vehicle with cleaner used vehicle or new vehicle, or decrease fleet size

# BACT Requirements: PM Target Not Met

- Apply highest level VDECS to 20% of total fleet maximum hp in previous year
  - May demonstrate 20% on average annually since beginning of rule
  - Apply Level 3s to all engines where available then consider Level 2s
  - Level 1s not considered
- Certain vehicles are exempt



# Requirements After the Final Compliance Date

- May only add vehicles if Tier 3 or cleaner and have the highest level VDECS
- Must continue to apply BACT requirements and report annually until targets for final compliance date are met
- Low use vehicle exemption ends

Fleet Category	Final Compliance Dates
Medium and Large	March 1, 2020
Small	March 1, 2025

# Compliance Extensions

- Manufacturer delays
- No VDECS
- Experimental strategies



# Reporting Requirements

- Initial reporting in 2008
  - Fleet as of March 1, 2008
- Staggered reporting dates base on fleet size category
- Annual reporting and compliance certification
  - Must report any changes since last reporting
    - Large fleets: 2009-2020
    - Medium fleets: 2010-2020
    - Small fleets: 2012-2025
- Compliance certification signed by a responsible official

# Summary of Items to Report

- Owner/contact information
- Vehicle information
  - Manufacturer, model, model year
- Engine information
  - Manufacturer, engine family, serial number, model year, maximum horsepower
- VDECS information
  - Date installed, verification level
- Other



# Labeling

- All vehicles must be labeled
  - ARB assigns unique Equipment Identification Number (EIN) after initial reporting
  - Fleets must label vehicles within 30 days
- EIN stays with equipment no matter who owns it
- Permanently affix or paint on left side of vehicle about 5 feet above ground

# Example Labeling



# Recordkeeping



- Records of all information reported
- Changes since last reporting period
- Vehicles not yet labeled – Purchase date or date entered the state
- VDECS failure
- Record retention – Retain records until vehicle retired and as long as owner has fleet. Transfer records to new owner if sold.

# Disclosure of Regulation Applicability

- Sellers must inform buyers that vehicles may be subject to the rule.
  - Provide disclosure in writing to the buyer



# Emission Benefits, Cost, and Cost- Effectiveness



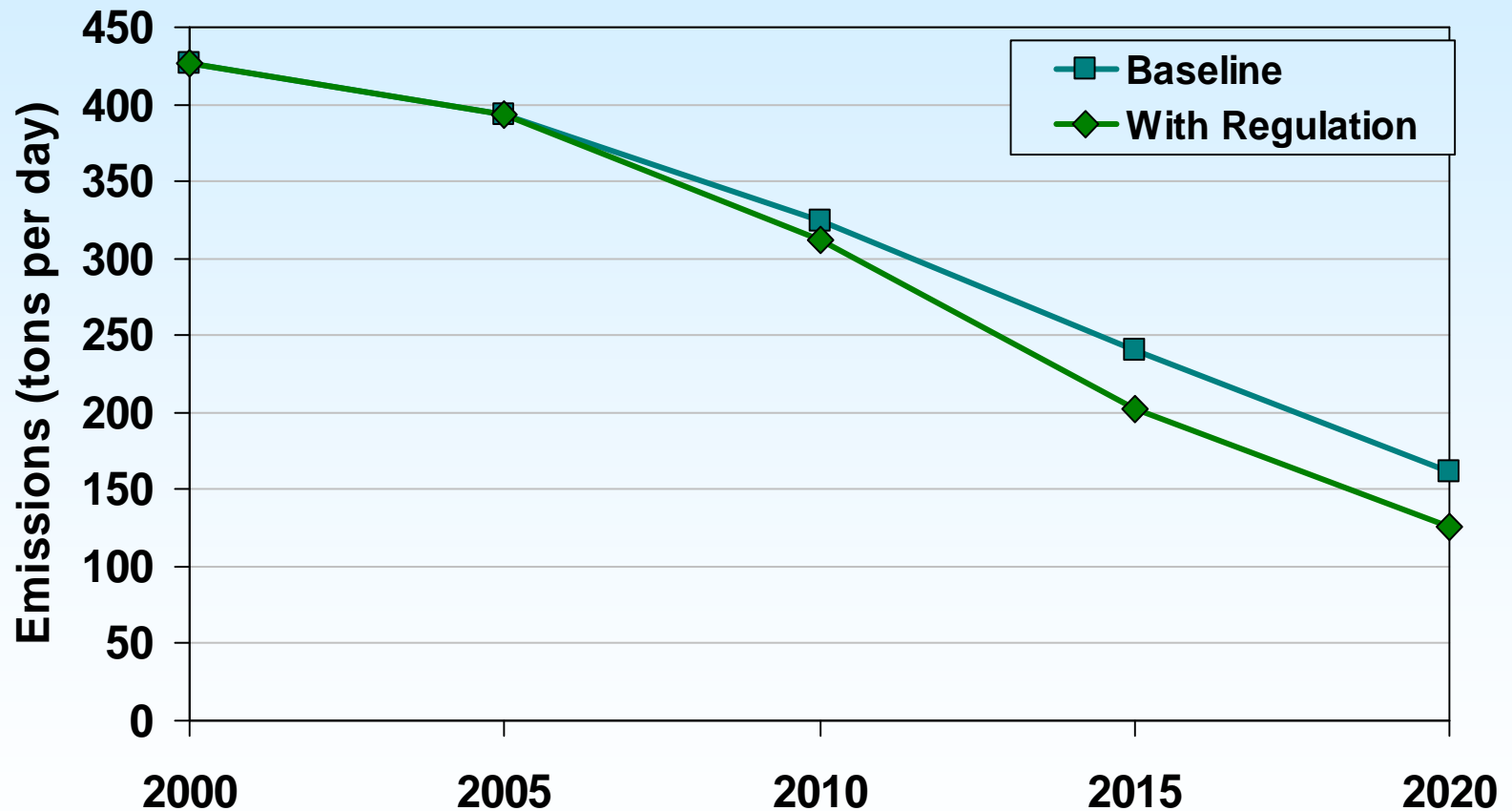


# Emission Benefits of Regulation

<b>NOx Emissions</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>
Benefits (tpd)	13	38	37
% Reduction	4%	16%	23%

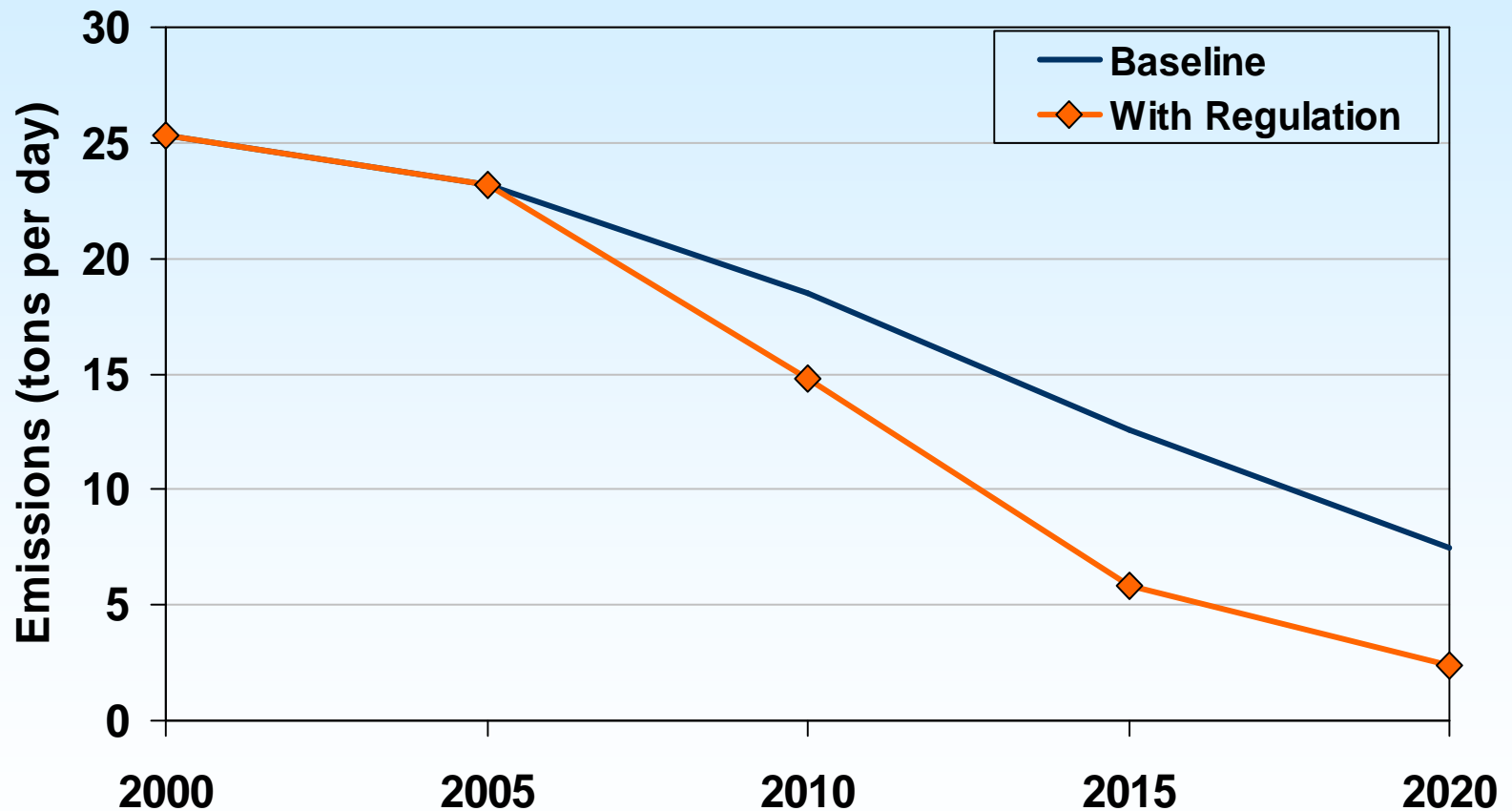
<b>PM Emissions</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>
Benefits (tpd)	3.7	6.8	5.0
% Reduction	20%	54%	68%

# NOx Emissions Inventory (tpd)\*



\* Construction, Mining, Industrial, GSE, and Workover Rigs

# PM Emissions Inventory (tpd)\*



\* Construction, Mining, Industrial, GSE, and Workover Rigs



# Cost/Benefits of Regulation

- Total cost of regulation ranges from \$2 to \$3 billion over 12 years
- Cost effectiveness
  - Attributes 50% of cost towards NOx and 50% towards PM benefits
  - \$28/lb PM
  - \$5/lb NOx
- Less than 0.5% of statewide construction value

# Statewide Cost/Benefits Analysis

- Evaluated costs and benefits on variety of fleets
  - Varying fleet age, size and equipment distribution
  - Varying purchase strategies
- Impacts of regulation will affect fleets differently



# Fleet Cost Analysis



# Fleet Analysis

- Evaluated actual fleets
  - Varying fleet age, size and equipment types
- Determined fleet actions needed to comply with regulation
- Compared costs and emissions benefits to normal fleet turnover

# Cost Analysis – Overview

- Calculated costs for:
  - Accelerated Turnover
  - Repowers
  - Retrofits
- Cost of cleaner vehicles estimated to increase with regulation
- Implementation consistent with regulation timelines
- No savings assumed for lower fuel consumption or lower maintenance costs at this time

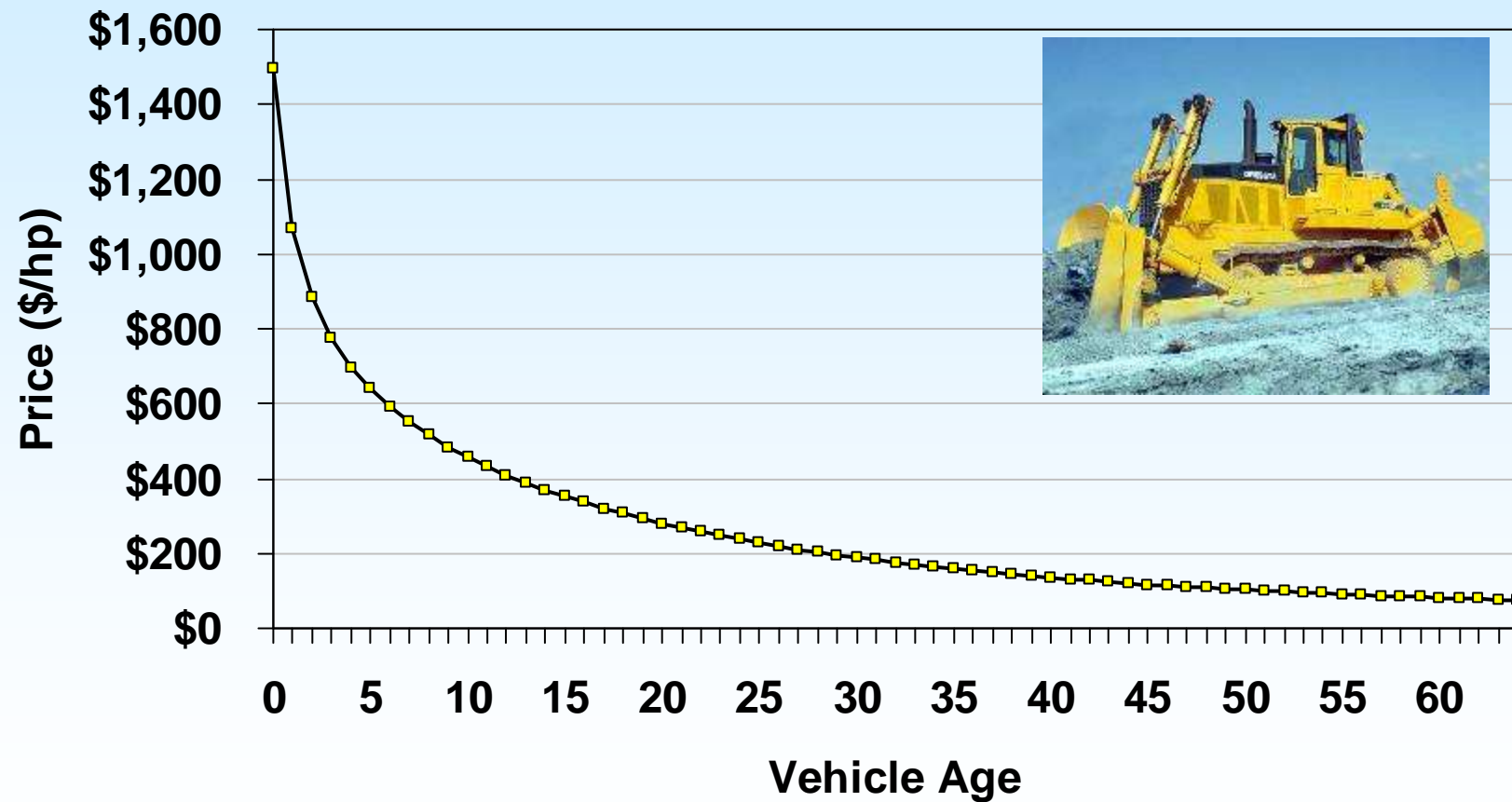
# Cost Analysis – Accelerated Turnover



Net salvage at 15 Years = \$5,000

$$\text{Cost for Emissions Reductions} = \$100,000 \times (5/20) - \$5,000 = \$20,000$$

# Crawler/Dozer Vehicle Price



# Cost Analysis – Repowers

- Average repower cost about \$280/hp
  - Primarily Tier 0 to Tier 2 or Tier 3
- Engines over 150 hp
- Not presumed to occur at time of rebuild
- No salvage value attributed to replaced engine



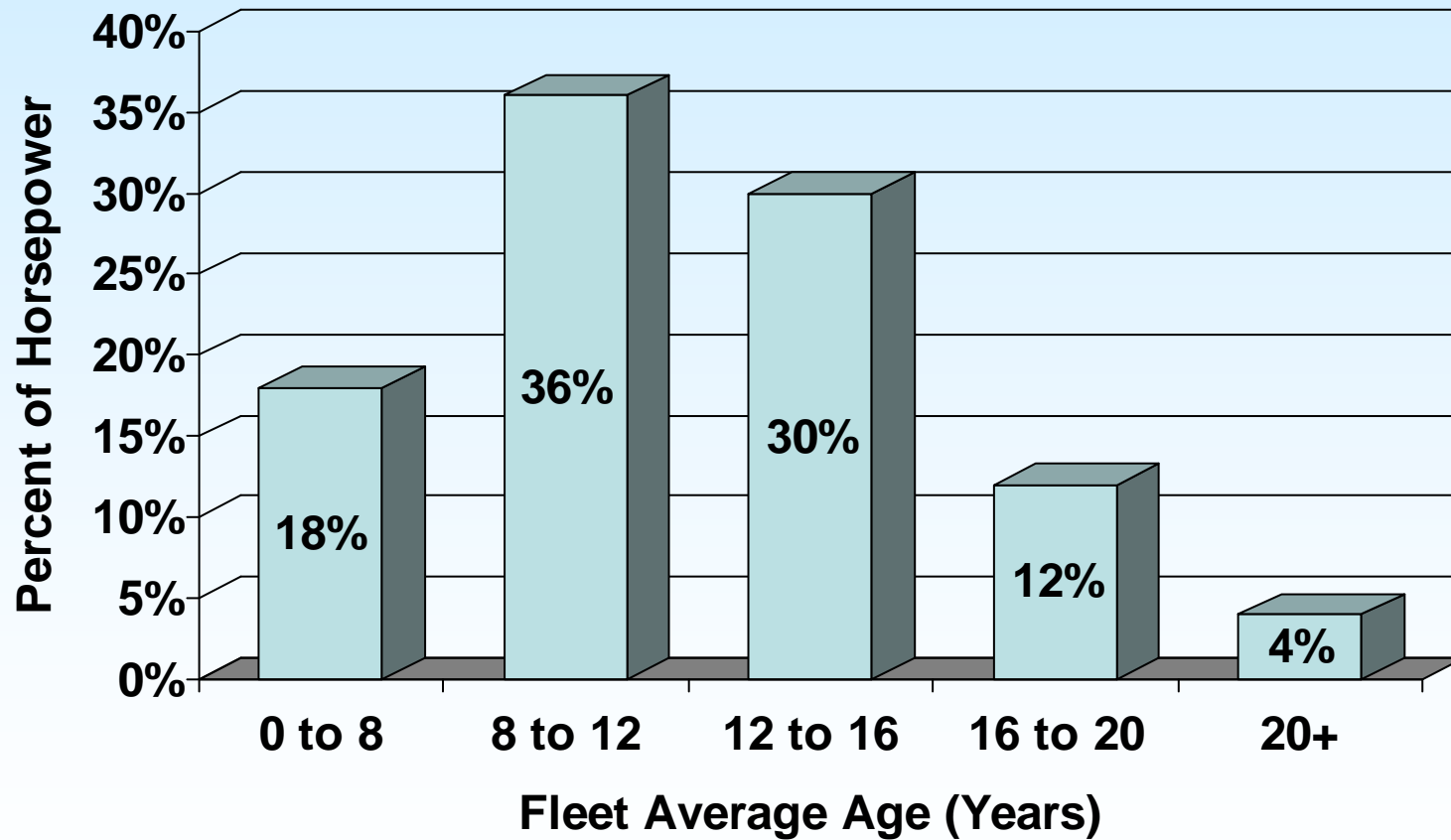
# Cost Analysis – PM Exhaust Retrofits

- Average Level 3 retrofit costs

Engine Size	Total Price
Less than 50 hp	\$8,000
50 to 175 hp	\$12,000
175 to 300 hp	\$18,000
Greater than 300 hp	\$30,000

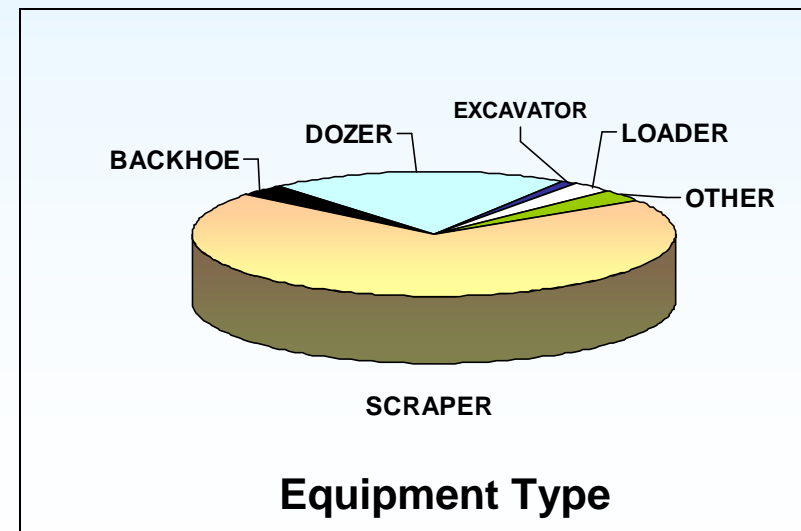
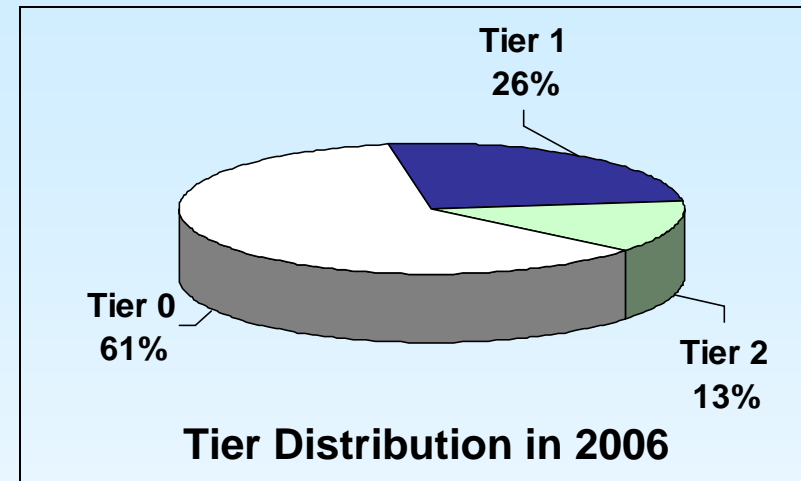
- Represents some active and passive systems

# Fleet Horsepower Distribution



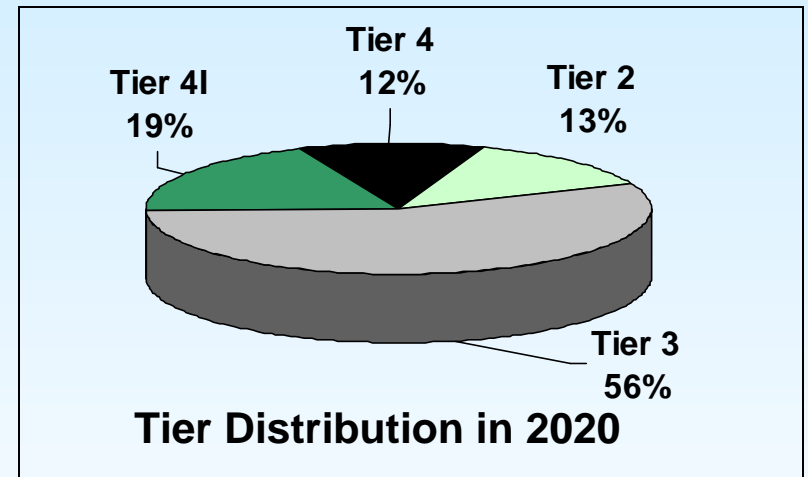
# Example Fleet Analysis

- Earth moving equipment
  - 101 engines totaling 41759 hp
  - Average engine size 413 hp
  - Average age of vehicles ~23 yrs
- Base case business model
  - Normal turnover 3% per year
  - Buys used equipment
  - No growth in fleet size



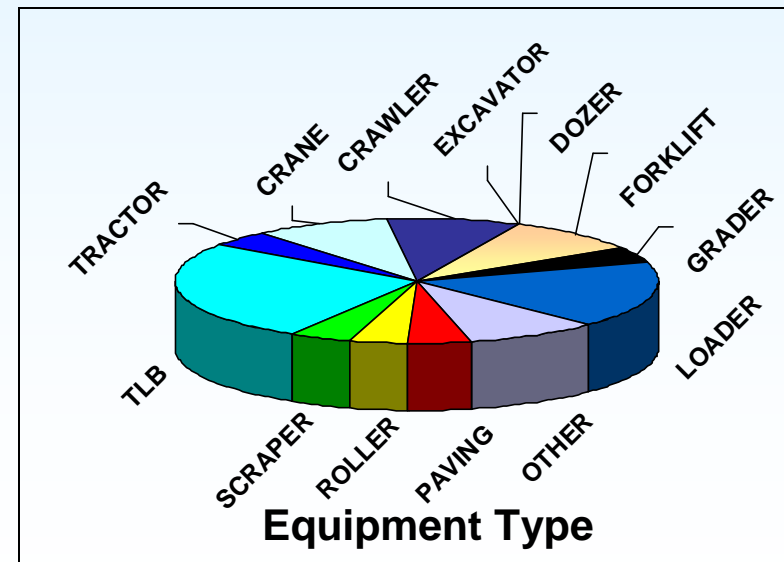
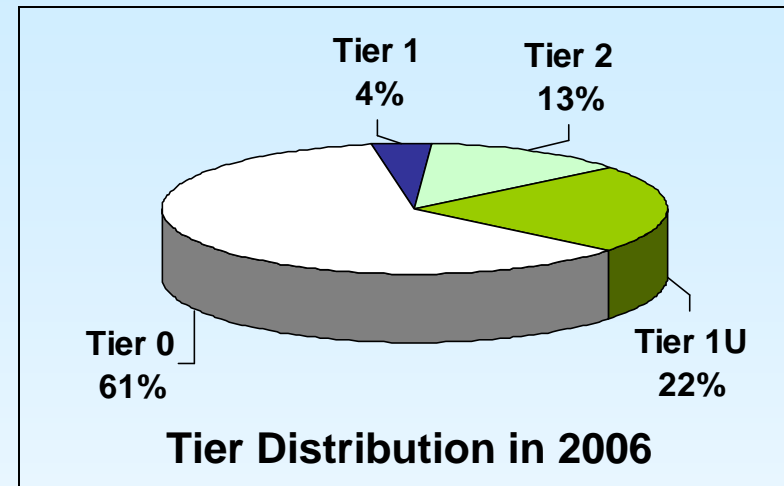
# Example Fleet Analysis

- Earth moving equipment
  - On BACT for beginning years
  - Buys used, repowers, and retrofits
  - Met PM targets starting in 2015
  - Met NOx target for 2020 only
  - 31% of fleet repowered by 2020
  - 50% of fleet retrofitted by 2015
  - 77% of non T4 vehicles retrofitted by 2020



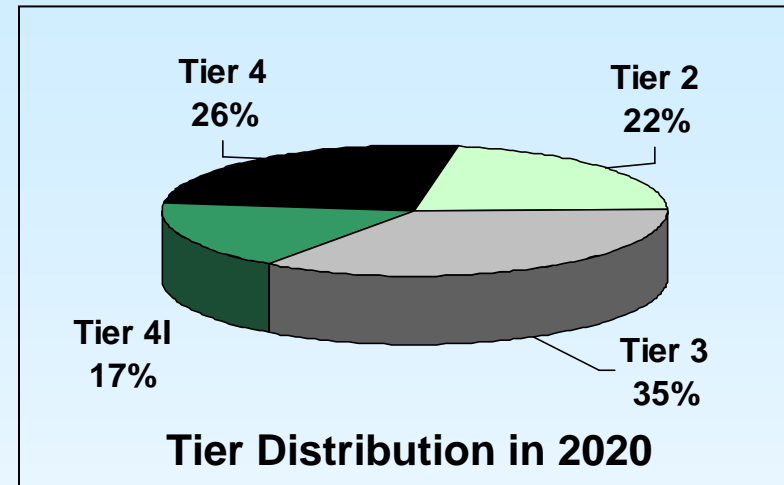
# Example Fleet Analysis

- Road maintenance equipment
  - 23 engines totaling 2928 hp
  - Average engine size 127 hp
  - Average vehicle age ~ 8 yrs
- Base case business model
  - Normal turnover about 7% per year
  - Primarily buy new equipment
  - No growth in fleet size

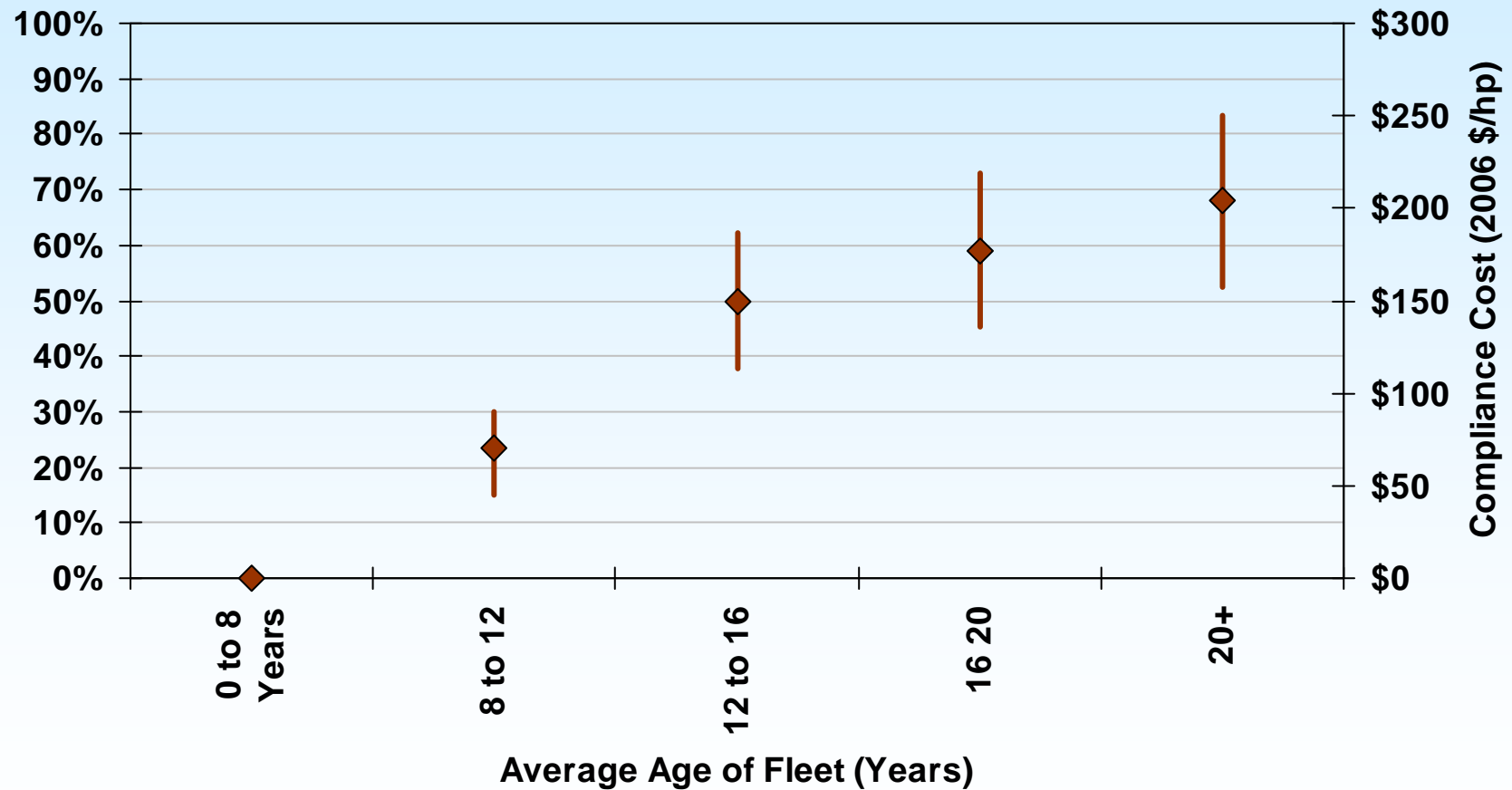


# Example Fleet Analysis

- Road maintenance equipment
  - Never on BACT
  - Turnover to new only
  - Met PM and NOx targets for every year
  - 45% of fleet retrofitted by 2015
  - 70% of non T4 vehicles retrofitted by 2020



# Compliance Costs of Regulation by Fleet Age



# Next Steps and Contacts





# Next Steps

- Now thru April 2007
  - Additional outreach and meetings with stakeholders
- February 2007
  - Last set of workshops
- Early March 2007
  - Staff report released
- April 2007
  - Consideration by Board

# Contacts

Erik White, Chief  
Heavy-Duty Diesel In-Use Strategies Branch  
[ewhite@arb.ca.gov](mailto:ewhite@arb.ca.gov)  
(916) 322-1017

Tony Brasil, Manager  
In-Use Control Measures Section  
[abrasil@arb.ca.gov](mailto:abrasil@arb.ca.gov)  
(916) 323-2927

Kim Heroy-Rogalski, Lead staff  
[kheroyro@arb.ca.gov](mailto:kheroyro@arb.ca.gov)  
(916) 327-2200

Michael Baker  
[mbaker@arb.ca.gov](mailto:mbaker@arb.ca.gov)  
(916) 323-2791

Elizabeth Yura  
[eyura@arb.ca.gov](mailto:eyura@arb.ca.gov)  
(916) 323-2397

---

Off-Road Regulation - [www.arb.ca.gov/msprog/ordiesel/ordiesel.htm](http://www.arb.ca.gov/msprog/ordiesel/ordiesel.htm)

Verified Devices - [www.arb.ca.gov/diesel/verdev/verdev.htm](http://www.arb.ca.gov/diesel/verdev/verdev.htm)